NATIONAL TRANSPORTATION SAFETY BOARD
Office of Aviation Safety
Washington, D.C. 20594

November 1, 2013

POWERPLANT GROUP CHAIRMAN'S FACTUAL REPORT

NTSB No: DCA13MA120

A. ACCIDENT

Location:	San Francisco International Airport (SFO) - San Francisco, CA
Date:	July 6, 2013
Time:	1128 Pacific Standard Time (PST)
Aircraft:	Boeing 777-200ER, Registration No. HL7742, Asiana Airlines, Flight 214

B. POWERPLANTS GROUP

Group Chairman:	Robert Hunsberger National Transportation Safety Board Washington, DC
Member:	Carol Horgan National Transportation Safety Board Washington, DC
Member:	Hongyang Bao Pratt & Whitney East Hartford, CT
Member:	John Koza Pratt & Whitney East Hartford, CT
Member:	Van Winters Boeing Seattle, WA
Member:	Hyoo Choi Korea Aviation and Railway Accident Investigation Board Sejong City, Republic of Korea

C. SUMMARY

On July 6, 2013 at 11:28 am Pacific daylight time, a Boeing 777, registration HL7742, operated by Asiana Airlines as flight 214, struck the seawall short of runway 28L at San Francisco International Airport. The airplane was destroyed by impact forces and fire. Three of the 291 passengers were fatally injured. The flight was a regularly scheduled passenger flight from Incheon International Airport, Seoul, Korea, and was operated under the provisions of *14 Code of Federal Regulations Part 129*. Visual meteorological conditions prevailed at the time of the accident.

A visual examination of the engines was conducted on scene at SFO. The No. 1 (left) engine was jettisoned from the airplane during the impact sequence and came to rest approximately 600 feet north of the main wreckage in the grass on the opposite side (right) of runway 28L. The right engine separated from the wing and came to rest against the right side of the fuselage.

The left engine exhibited fan blade airfoil fractures opposite the direction of rotation. The right engine exhibited fan tip bending opposite the direction of rotation and hard object impact damage on the fan blade airfoil leading edges. A review of the flight data recorder (FDR) confirmed that the engine parameters were normal during approach. After the throttles were advanced to attempt a go-around, both engines accelerated above 90% N1 thrust levels in accordance with the design specification.

D. DETAILS OF THE INVESTIGATION

1.0 ENGINE INFORMATION

1.1 ENGINE HISTORY

According to Asiana Airlines records the engines had accumulated the following history (**Table 1**).

	Left Engine (No. 1)	**Right Engine (No. 2)**
Engine Serial Number (ESN)	P222240	P222186
Date of Manufacture	30 DEC 2005	14 MAR 2002
Time Since New (hours)	31,273	48,008
Cycles Since New (CSN)	4,485	7,126
Date of Last Shop Visit	22 APR 2013	04 MAY 2009
Time Since Last Shop Visit (hours)	444	20,080
Cycles Since Last Shop Visit	62	2,671

Table 1- Engine History

1.2 ENGINE DESCRIPTION

The accident airplane was powered by two Pratt & Whitney (P&W) PW4090 turbofan engines. The PW4090 is a dual-spool, axial-flow, high bypass turbofan engine that features a 1-stage fan, a 6-stage low pressure compressor (LPC), a 11-stage high pressure compressor (HPC), an annular combustor, a 2-stage high pressure turbine (HPT), and a 7-stage low pressure turbine (LPT).

According to the Federal Aviation Administration Type Certificate Data Sheet E46NE, Revision 8, dated January, 23 2012, the PW4090 engine has a maximum continuous sea level thrust rating of 74,950 pounds and a takeoff sea level thrust rating of 91,790 pounds flat rated to 59^{o}F (15^{o}C)[1].

All directional references to front and rear, right and left, top and bottom, and clockwise and counterclockwise are made aft looking forward (ALF). A diagram identifying engine flanges is provided in (**Figure 1**).

[1] Flat-rated to a specific temperature indicates that the engine will be capable of attaining the rated thrust level up to the specified inlet temperature.

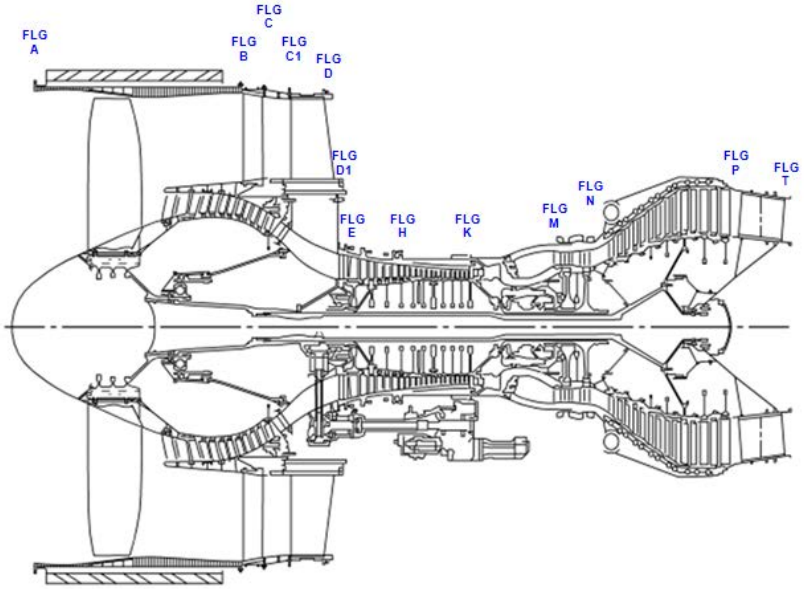

Figure 1- PW4090 Flange Reference

2.0 ON-SITE ENGINE EXAMINATION

2.1 ENGINE WRECKAGE PATH

The airplane came to rest to the left of runway 28L, right side up and with the nose of the airplane pointing northwest. The left engine with the pylon still attached was found separated from the wing and resting on its right side. The engine was located approximately 600 feet north of the main wreckage on the opposite side (right side) of runway 28L (**Photo 1**). Ground scars were noted on the runway and into the grass to the right of runway 28L where the engine had skidded after separation from the wing. Fan blade fragments were found in a localized area on the runway in-line with the engine ground scar tracks (**Photo 2**). Separated sections of the engine cowls and thrust reverser were also located on the runway and in the grass leading to the engine.

Photo 1- Left Engine, Right of Runway 28L

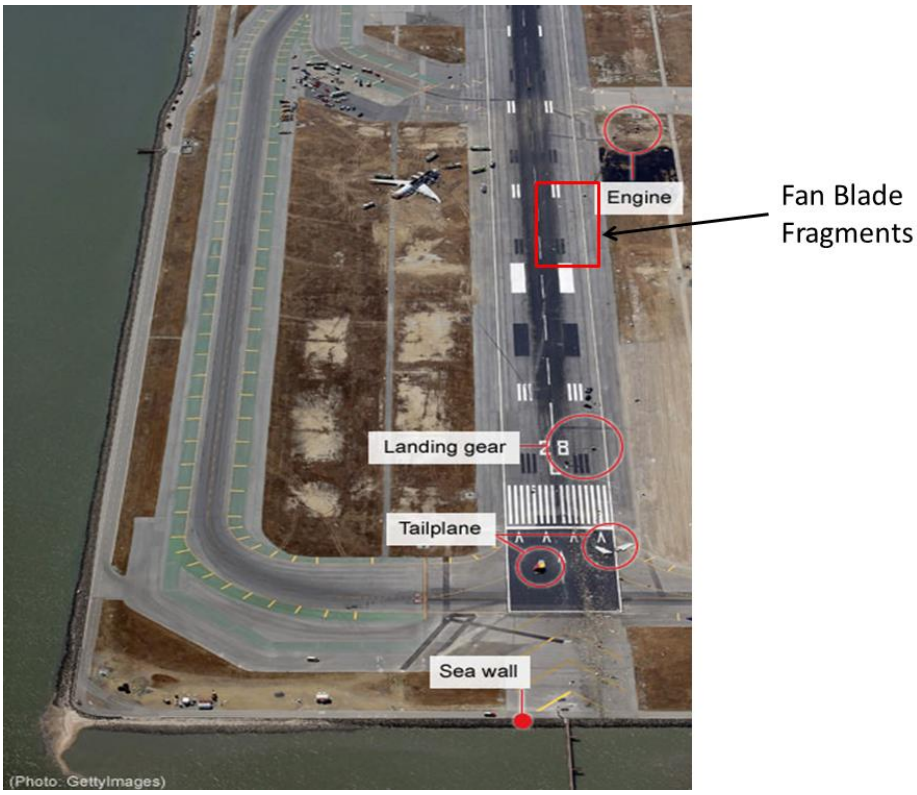

Photo 2- Aerial Wreckage Photograph, Majority of Fan Blade Fragments Recovered From Area Within the Red Box

The right engine was separated from the wing and found on its right side resting against the right side of the fuselage (**Photo 3**).

Photo 3- Right Engine

2.1 LEFT ENGINE (ESN P222240)

The left engine had no indications of fire or uncontainment. The engine data plate serial number located on the fan case matched Asiana Airlines records. The cowlings were separated from the engine except for an approximately six inch (axially) piece of the inlet cowl which remained attached to the 'A' flange (**Photo 4**). The thrust reverser and tail cone were separated from the engine. A visual inspection of the thrust reverser actuators confirmed it was in the stowed in the position (**Photo 5**).

Photo 4- Left Engine

Photo 5- Left Engine Thrust Reverser Wreckage, Stowed Position

2.1.1 Compressor Fan

The fan case was ovalized and exhibited inward deformation at 6, 9, and 12 o'clock. All the fan blades were fractured between 8 and 20 inches outboard from the blade platform (**Photo 6**).[2] The fan case was fractured circumferentially from 3 to 5 o'clock aft of the 'C' flange, and 5 to 6 o'clock aft of the 'B' flange (**Photo 7**). The fan blade rub strip material located around the circumference of the fan case exhibited rubs and gouging 360 degrees around with the most severe damage located at 6 and 12 o'clock (**Photo 8**). Rub strip damage aft of the normal blade path was identified at the 6 o'clock position (**Photo 9**). The fan blade fractures and the case rub damage were consistent with high speed fan rotation at the time of impact.

[2] Per P&W drawings fan blade airfoils on the PW4090 engine are 37.55 inches in length. The engine has 22 fan blades.

Photo 6- Fan Case Ovalization and Blade Damage

Photo 7- Fan Case Fracture Aft of 'B' Flange

Photo 8- Fan Rub Strip- (Left) 6 o'clock, (Right) 12 o'clock

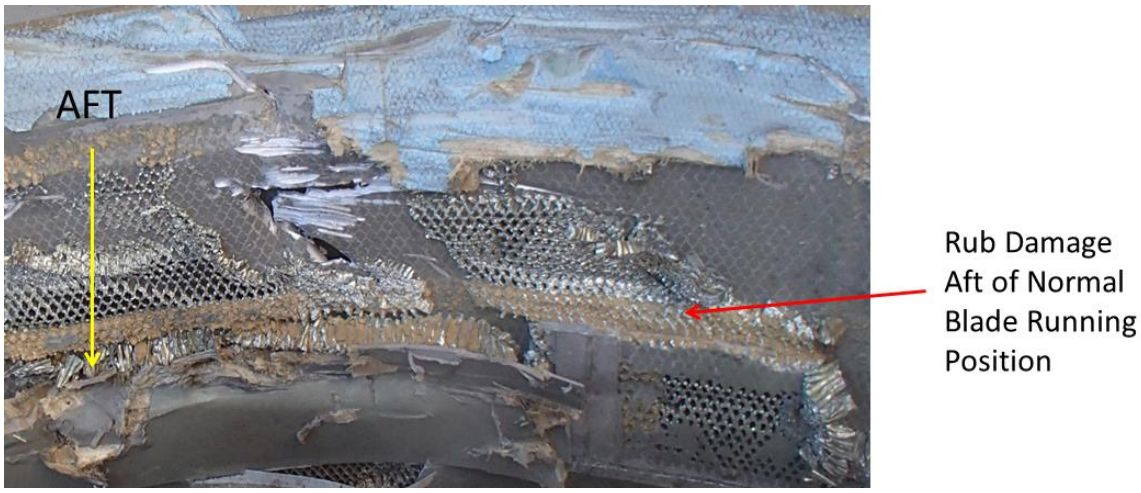

Photo 9- Close Up of Rub Damage at 6 o'clock

2.1.2 Low Pressure Turbine

All visible LPT 7th stage blades and vanes were intact and appeared in good condition (**Photo 10**). No loose metal debris was found in the exhaust.

Photo 10- Low Pressure Turbine Blades, Intact

2.1.3 Fuel Spar Valve

The left engine fuel spar valve[3] located at the engine mount on the wing was found in the closed position (**Photo 11**).

Photo 11- Left Fuel Spar Valve, Closed Position

[3] The spar valve is a low pressure fuel shut off valve which prevents an overboard fuel leak in the event of engine separation from the wing. The spar valve is designed to close when the fire handle is pulled.

2.2 RIGHT ENGINE (ESN P222186)

The right engine had no indications of uncontainment but exhibited thermal damage and sooting along the top and left side exterior surfaces as viewed from the engine's resting position (**Photo 12**). The oil tank located on the top of the engine was partially melted and the areas around the tank were heavily sooted and thermally damaged (**Photo 13**). The engine data plate serial number located on the fan case matched Asiana Airlines records. A visual inspection of the thrust reversers confirmed they were in the stowed position (**Photo 14**).

Photo 12- Top View of Engine with Thermal Damage on Left Side

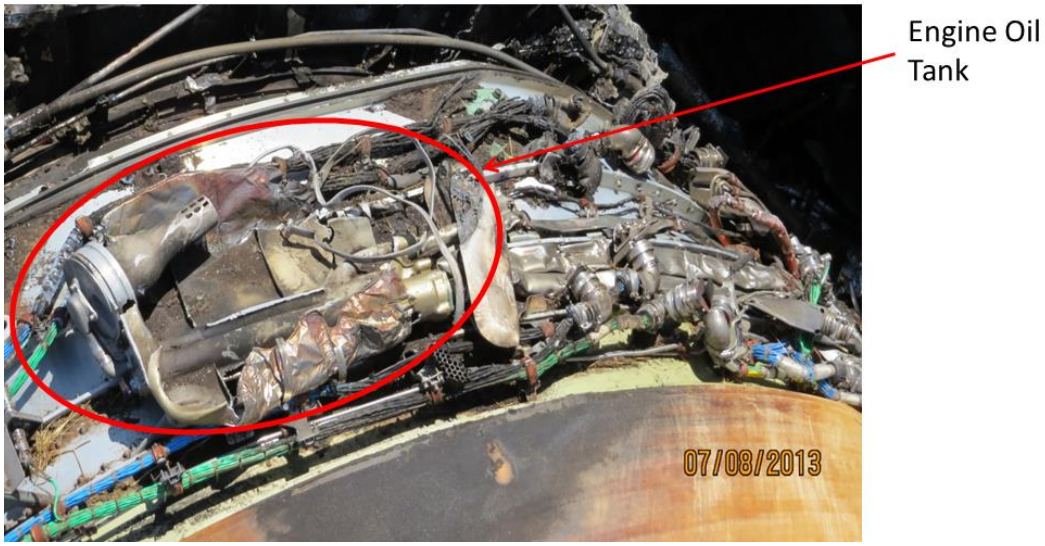

Photo 13- Engine Oil Tank Location, Thermally Damaged

Photo 14- Right Engine, Thrust Reverser in Stowed Position

2.2.1 Compressor Fan

The fan blades were intact but exhibited varying levels of hard body impact damage on the leading edge consistent with foreign objects entering the fan while the engine was rotating at high speed (**Photo 15**). Multiple fan blade tips exhibited curling opposite the direction of rotation. The fan case rub strips had gouging and rubs 360 degrees around but was most severe from 3 to 6 o'clock (**Photo 16**). Fan blades and fan exit guide vanes exhibited sooting and thermal deformation in the upper left quadrant (9 to 12 o'clock) as viewed from the engine's resting position, consistent with thermal distress that was seen on the external engine surfaces (**Photo 17**).

Photo 15- Fan Blade Leading Edge Damage

Photo 16- Fan Blade Rub Strip, 3 to 6 o'clock

Photo 17- Fan Blade Rub Strip, 3 to 6 o'clock

2.2.2 Low Pressure Turbine

All visible LPT 7th stage blades and vanes were intact and appeared in good condition (**Photo 18**). No loose metal debris was found in the exhaust.

Photo 18- LPT Blades, Intact

2.2.3 Right Fuel Spar Valve

The right engine fuel spar valve was in the open position. The wiring to the spar valve actuator was separated (**Photo 19**).

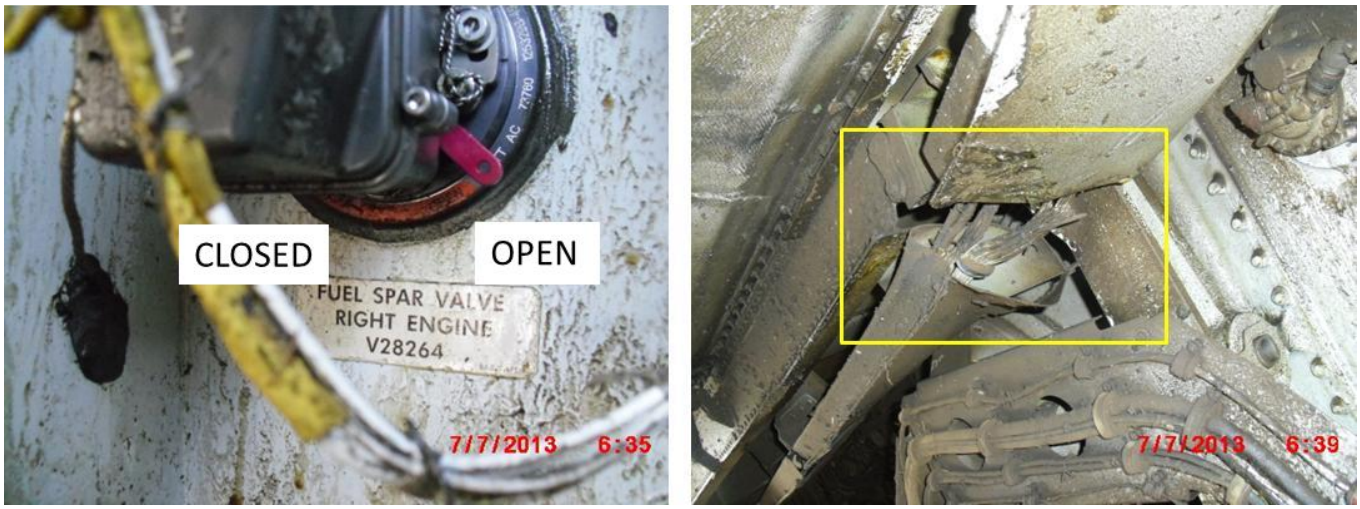

Photo 19- (Left) Right Fuel Spar Valve, Open (Right) Wire Bundle Separated

3.0 FLIGHT DATA RECORDER

The FDR was downloaded and analyzed at the NTSB Vehicle Recorders Lab in Washington, DC. Key engine parameters were plotted to examine whether the engines were operating according to design specifications prior to impact (**Figures 2 and 3)**[4,5]. During approach both engines' TLA and N1 parameters were at idle. The crew advanced both engine throttles to attempt a go-around. When the throttles were fully advanced, 90% N1 thrust levels were reached in approximately 6 seconds by the left engine and approximately 7 seconds by the right engine (**Tables 2 and 3**). The acceleration time for both engines met the performance requirement stated in the design specification.

[4] The Boeing 777-200ER/PW4090 design specification states that the engines shall take no more than 8 seconds to accelerate from idle to a thrust level sufficient to maintain a 3.2% climb gradient. For the PW4090 engine, the thrust level required to meet this 3.2% climb gradient is 90% of maximum thrust.

[5] The Boeing 777-200ER FDR records engine parameters such as throttle lever angle (TLA), N1 (low pressure rotor) and N2 (high pressure rotor) speeds at one sample per second.

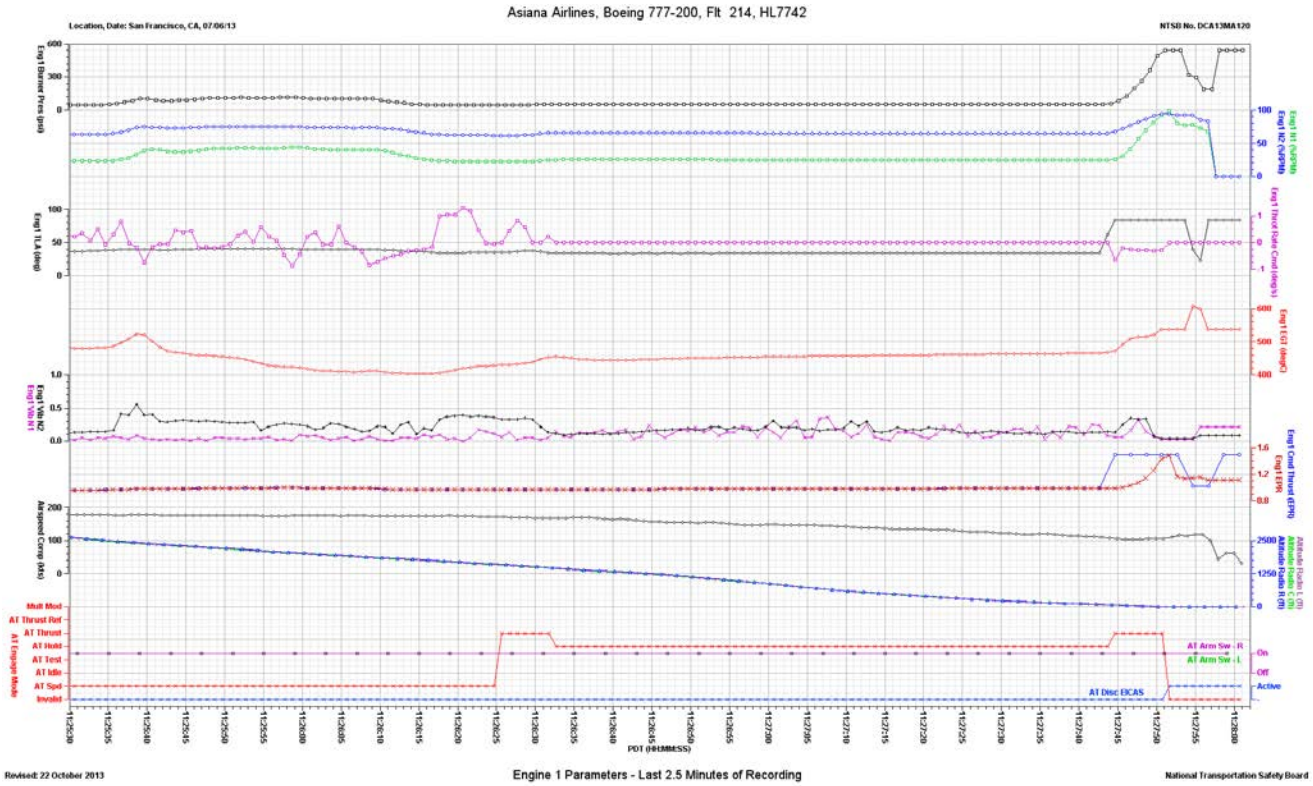

Figure 2- Left Engine FDR Plot

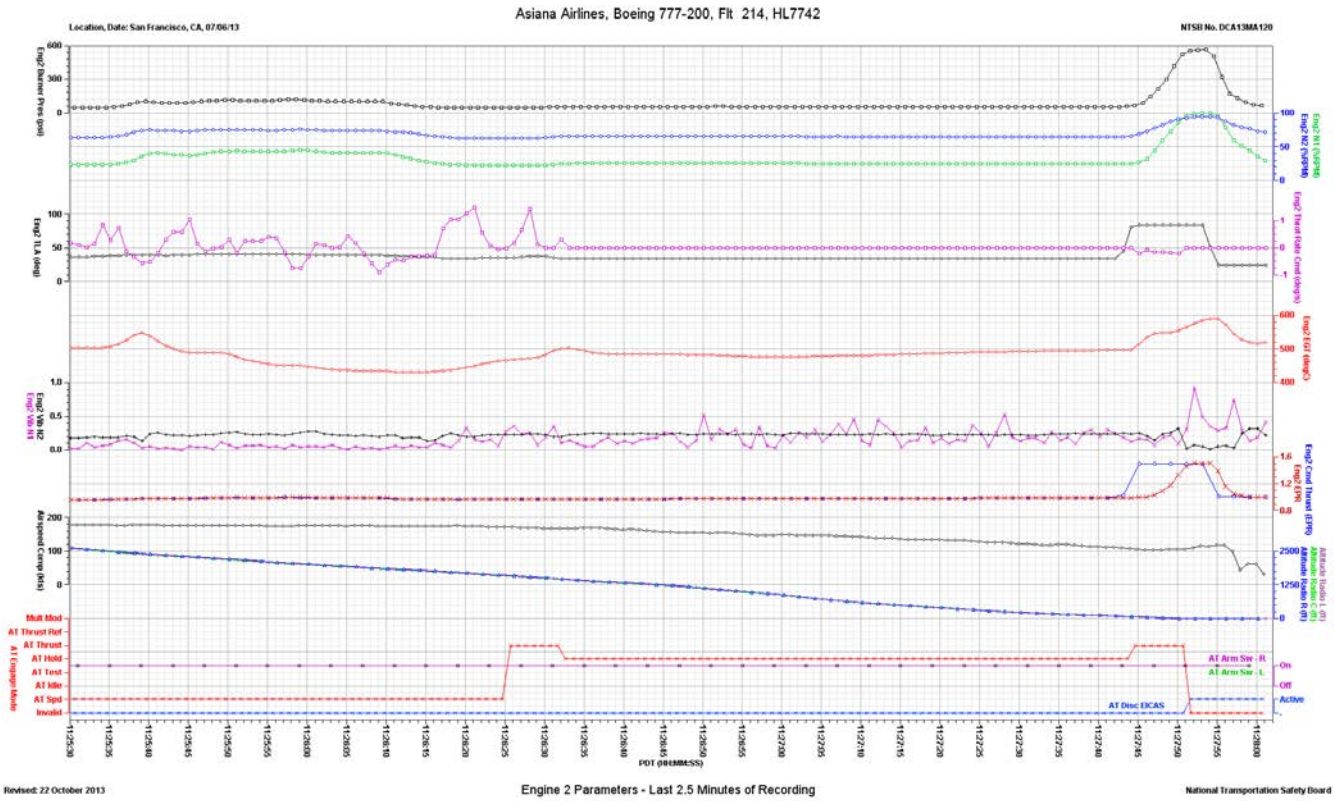

Figure 3- Right Engine FDR Plot

FDR Timestamp (seconds)	Engine N1 Speed (%)	Throttle Lever Angle
97904.02	24.25	
97904.07		34.13
97905.02	24.25	
97905.07		62.64
97906.02	25.63	
97906.07		84.11
97907.02	30.38	
97907.07		84.11
97908.02	41.13	
97908.07		84.11
97909.02	56.25	
97909.07		84.11
97910.02	69.38	
97910.07		84.11
97911.02	81.5	
97911.07		84.11
97912.02	92.75	
97912.07		83.75
97913.02	98.38	
97913.07		83.75

Table 2- Left Engine FDR Parameters

FDR Timestamp (seconds)	Engine N1 Speed (%)	Throttle Lever Angle
97903.52	24.13	
97903.57		34.13
97904.52	24.13	
97904.57		44.34
97905.52	24.38	
97905.57		80.94
97906.52	26.5	
97906.57		84.11
97907.52	32.0	
97907.57		84.11
97908.52	44.0	
97908.57		84.11
97909.52	59.63	
97909.57		84.11
97910.52	73.13	
97910.57		84.11
97911.52	86.13	
97911.57		84.11
97912.52	95.63	
97912.57		83.75

Table 3- Right Engine FDR Parameters

4.0 AUXILIARY POWER UNIT (APU) INFORMATION

4.1 APU HISTORY

According to Asiana Airlines records the APU had accumulated the following history (**Table 4**):

Items	
APU Serial Number	P-1615
Date of Manufacture	26 MAY 2005
Time Since New (hours)	11,924
Cycles Since New	9,600
Date of Last Shop Visit	26 APR 2010
Time Since Last Shop Visit (hours)	3,795
Cycles Since Last Shop Visit	3,449

Table 4- APU History

4.2 APU DESCRIPTION

The accident airplane was equipped with a single Honeywell GTCP 331-500(B) APU located in the tail of the airplane. The GTCP 331-500(B) APU is a single spool gas turbine engine consisting of a 2-stage centrifugal compressor, a reverse flow annular combustion chamber, a 3-stage axial turbine, a direct driven gearbox, and a centrally located controller.

The APU supplies pneumatic power for main engine starting, cabin air conditioning, and air driven hydraulic units. The APU also supplies power to drive an electrical generator.

5.0 APU FINDINGS

The APU was found separated from the airplane on the right side of the runway 28L center line, near the threshold (**Photo 20**). There was no evidence of fire or uncontainment. The APU was not further analyzed due to a lack of evidence suggesting it was a causal factor in the accident.

Photo 20- Auxiliary Power Unit

Robert Hunsberger
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Powerplants